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Keywords

hazard, transforming, policy, shark, learning, ocean, users, encounter, western, australia

Disciplines

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Transforming shark hazard policy: learning from ocean-users and shark encounter in Western Australia

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Killing sharks is a popular strategy for reducing risk for beach-goers and ocean-users. But the effectiveness of kill-based strategies is debated and the ecological and economic costs are high. In Western Australia the state government introduced new policy in 2012 in response to shark-related fatalities, to track, catch and destroy sharks deemed to pose an 'imminent threat' to beach-goers. This paper reports on a survey of Western Australia-based ocean-users, and pursues two aims: to develop an understanding of the experiences of ocean-users in encountering sharks; and to learn about the attitudes of ocean-users towards shark hazard management. The research finds that people encounter sharks often, without harm, and that most ocean-users adapt their practices in order to reduce personal risk. The majority of ocean-users oppose the kill-based elements of the new policy, and kill-based shark hazard management strategies more broadly. Rather, ocean-users strongly support further research and education focusing on shark behaviour and shark deterrents, and approaches that enable people to understand and accept risks associated with ocean use. These findings present opportunity to refocus debates about shark hazard management on non-lethal strategies in concert with better educating publics so they can make informed decisions about their ocean-based activities.

Keywords

shark; shark attack; marine governance; ocean-user; ocean safety; Australia

1. Introduction

Over a ten-month period during 2011 and 2012, five human fatalities tragically occurred in Western Australia (WA) as a result of shark bite. In reporting the incidents print and television media labelled WA 'Shark attack capital of the world' (Tedmanson, 2012). Following the fifth fatality in July 2012, the WA government made substantial change to the state's environment and fisheries policy, allowing proactive killing of sharks sighted 'in close proximity to beachgoers' (Government of Western Australia 2012). After a sixth fatality in November 2013 the policy was broadened further. To supplement the proactive kill strategy two 'Marine Monitored Areas' (MMAs) were established; one off Perth's metropolitan beaches and the other in the state's southwest, a region popular with surfers and tourists. Each MMA stretches from the shoreline 1km into the Indian Ocean. A series of

large baited hooks – known as drumlines – was deployed at the boundary of each MMA to catch sharks. Private fishing companies initially contracted to patrol each zone were tasked with killing sharks over 3m in length caught on the drumlines or spotted inside the MMAs. Each area thus represented what the media described as a ‘kill zone’ within which professional fishers were paid to patrol, destroy and dispose of sharks (Hopkin, 2013).

The program targeted tiger sharks (*Galeocerdo cuvier*), bull sharks (*Carcharhinus leucas*) and great white sharks (*Carcharodon carcharius*), three species identified in Australia as potentially ‘dangerous to humans’ (Australian Government Dept Env. n.d.; Department of Fisheries Western Australia, 2013). The drumlines were set and maintained between 25 January and 30 April 2014. Two million dollars was allocated to this strategy, as part of a \$6.85 million shark mitigation package, and in addition to a \$13.65 million package announced in the previous year. In order to undertake the fatal elements of the strategy the WA government sought and received exemptions from its responsibilities under the *Environment Protection and Biodiversity Conservation Act 1999*, *Fish Resources Management Act 1994* (WA) and the *Wildlife Conservation Act 1950* (WA). In June 2014 the WA government proposed to continue the lethal approach to sharks for a further three years. Drumlines were to be set annually between 15 November and 30 April (peak beach-use season). But in September the state’s Environmental Protection Authority recommended against the proposal, citing the ‘high degree of scientific uncertainty about impacts on the viability of the south-western white shark population’ (EPA, 2014).

This paper responds to recent human-shark encounters, policy change, and associated public debate about use and management of marine environments. In particular, it investigates the experiences and attitudes of ocean-users. The paper pursues two aims: to develop an understanding of the experiences of ocean-users in encountering sharks; and to learn about the attitudes of ocean-users towards shark management. Despite the high public profile of shark bite events and recent policy change in WA, research has not yet focused on the people who use the ocean on a regular basis, and who are therefore most likely to come into contact with sharks; a group described here as ‘ocean-users’. This group comprises swimmers, board riders, divers, fishers, Surf Life Savers, and people who undertake other recreational, volunteer, and professional activities on or in the ocean as part of everyday life.

2. Killing sharks as hazard mitigation policy

The WA government's Shark Hazard Mitigation Strategy is not isolated in its lethal approach towards managing human-shark encounters. On Australia's east coast, New South Wales (NSW) has operated a shark meshing program since 1937 (NSW Department of Primary Industries, 2013). There, specialised nets are placed along 51 of the state's popular beaches between September and April each year. The nets are designed to entangle and trap sharks. In 2011-12 contractors caught 158 sharks; 102 were killed (a mortality rate of 65%), and only 15 were species identified as dangerous to humans (NSW Department of Primary Industries, 2013). Following two fatalities in 1961 the state of Queensland (QLD) implemented a stringent policy approach to sharks, including widespread use of baited drumlines in addition to shark nets (*Fisheries Act 1994* [QLD]). In 2012, 753 sharks were caught by private fishing contractors off the QLD coast, a catch increase of 25% over the previous five years (Department of Agriculture, Fisheries and Forestry, 2014). The QLD shark control program is particularly lethal. The average annual mortality rate is 94%, with three-quarters of all sharks dying while ensnared on baited hooks (per. comm. QLD Shark Control Program manager, Feb 2014).

Outside Australia a shark control program employed in South Africa's KwaZulu-Natal Province also uses shark nets and baited drumlines (*KwaZulu-Natal Sharks Board Act [2008]*; KwaZulu-Natal Sharks Board, 2011). According to the program's board the nets (totalling 23.4km) and drumlines 'function by reducing shark numbers in the vicinity of protected beaches, thereby lowering the probability of encounters between sharks and people at those beaches' (KwaZulu-Natal Sharks Board, 2011; see also Cliff and Dudley, 2011). In other words, human risk is reduced by killing large numbers of sharks, most of which pose no threat to human life. In July 2013 the French territory of Reunion Island introduced measures in response to a number of incidents, including three shark-related fatalities, in the preceding two years. Actions included prohibition of swimming, surfing and body boarding in particular areas, and culling of 90 sharks (45 bull and 45 tiger sharks), the latter promoted as part of an existing study into food safety and shark risk management. By categorising these killings as part of a scientific study, authorities have been exempt from their legal responsibility to protect species, including bull sharks (Conniff, 2013; Nickel, 2013). As in WA, action to kill sharks is not legislated, but enabled through exemption from existing legislation.

While shark nets have been used in KwaZulu-Natal since 1952, deployment of baited drumlines is a more recent development. According to Cliff and Dudley (2011, 706) the decision to use drumlines in KwaZulu-Natal was 'a direct result of a detailed comparison with the shark-control programs in Queensland and New South Wales' (see also KwaZulu-Natal Sharks Board, 2011). A 2009 report

described the NSW Shark Meshing Program as ‘effective in reducing the incidences of fatal shark attack at major metropolitan beaches, with only one fatal shark attack on a netted beach since the SMP began’ (Green et al., 2009, 1). But the effectiveness of kill-based approaches is questionable and geographically variable (McPhee, 2012). Between 1959 and 1976 shark culling carried out across the Hawaiian Islands killed 4668 sharks. Yet there was no measurable reduction in the rate of shark bite over the 17-year period, or in the years since the culling ceased (Holland et al., 1999; Wetherbee et al., 1994).

The impacts of kill-based control programs on shark populations and marine ecology are substantial, including negative implications for populations of threatened shark species, potential effects of removal of large predators from near-shore areas, and mortality of diverse by-catch of non-target shark species, rays, turtles and cetaceans (Cliff and Dudley, 2011; MCPhee, 2012). O’Connell et al. (2014, 38) have noted that ‘anthropogenic sources of shark mortality have had a major negative influence on local and migratory shark populations’. The NSW Shark Meshing Program is listed as a Key Threatening Process under both the *Fisheries Management Act 1994* (NSW) and *Threatened Species Conservation Act 1995* (NSW). The Office of Environment and Heritage defines a Key Threatening Process as something that threatens or potentially threatens the survival or evolutionary development of a species, population or ecological community. Further, numerous unknowns complicate interpretation of catch data from shark control programs, including increases in beach use by people, fishing pressure outside shark program areas, and scientific understanding of shark behaviour and geographic movement (Green et al., 2009; Reid et al., 2011).

Over the last decade lethal approaches to reducing risk of shark bite have also been adopted in New Zealand, Egypt, Russia, the Seychelles and Mexico (Neff and Yang, 2013). In popular coastal regions where tourism and ocean use represent important sources of leisure and revenue, killing and culling policies for managing human-shark encounters are increasingly prevalent. An increase in lethal approaches towards managing sharks comes despite questionable effectiveness in reducing risk to human safety, and considerable environmental and economic cost (Cliff and Dudley, 2011; Gibbs and Warren, 2014; Green et al., 2009; MCPhee, 2012; O’Connell et al., 2014; Wetherbee et al., 1994).

3. Surveying attitudes to sharks and shark hazard policy

Effective shark hazard mitigation policy is dependent on better understanding of shark behaviour and ecology, efficacy of mitigation technologies and techniques, and cultural attitudes and practices. As such, policy should be informed by both the physical and social sciences. A number of surveys

have been undertaken in recent years investigating attitudes to sharks and shark hazard management. Two studies of public perception have identified positive attitudes or values associated with sharks. Friedrich et al. (2014) investigated public perceptions of sharks and shark conservation in the UK, focusing on people who have a demonstrated interest in marine environments. Their survey of 135 respondents in June-July 2011 found that regular aquarium visitors, frequent coast visitors, and people with experience of sharks in the wild tended to have more positive and stronger pro-conservation attitudes towards sharks than others. In a pilot study of public attitudes to sharks before and after a shark bite incident in Cape Town, South Africa, Neff and Yang (2013) surveyed 100 respondents across two beach locations in June and October 2011. They found that value attributed to endemic shark populations, and confidence in beach safety organisations, remained unchanged following a shark bite incident.

Two recent studies conducted by private research firms in response to events in WA have found a high degree of opposition to culling or killing sharks as a hazard mitigation strategy. A randomised survey of 500 people conducted by UMR Research found that 83% of Australians have not changed how they use the ocean as a result of the risk of shark attack. Further, 82% did not think sharks should be killed, and believed that people enter the water at their own risk (Dorling, 2014). A WA government-commissioned survey aimed to understand views of personal accountability towards mitigation of shark risk, and how fear of sharks has altered community behaviour (Marketforce, 2013; Orr, 2014). The study surveyed 768 WA residents in April 2013. It found that the majority of respondents (46% measured on a five-point Likert scale) had not changed their beach use since 2011; of those who had decreased their use, 95% cited personal circumstances or preference as the explanation (less than 6% mentioned sharks). Most respondents (53%) believed more needed to be done about sharks, but culling is not the answer; 29% believed nothing needed to be done; only 19% believed that sharks should be culled. The majority (56%) identified the individual (from four options) as most responsible for safety with respect to sharks. Regarding what can be done to ensure individuals take responsibility for their safety, the top three unprompted responses were 'educate people', 'be aware/common sense' and 'outdoor signs and instructions' (Marketforce, 2013). Details and data from these two studies have not been publicly released or peer-reviewed.

There is also a developing literature surveying experiences and attitudes of tourists who pay to encounter sharks, usually through scuba diving or snorkelling operators (Dobson, 2008; Bentz et al., 2014). Cage diving in South Africa and South Australia is another burgeoning commercial enterprise facilitating close encounters with sharks (Dicken and Hosking, 2009). Research on tourists'

experiences in these contexts has argued for the usefulness of shark-based tourism for educating the public on, and galvanising support for, shark conservation (Topelko and Dearden, 2005; Ward-Paige, 2014). These studies aside, there is little research into ocean-users' experiences with sharks in non-controlled settings, perceptions of risk of shark bite, existing strategies employed to reduce risk, and attitudes towards shark management. Such information is valuable for designing and implementing more ethical and ecologically sustainable marine policy.

4. Methods

This paper reports on a survey of ocean-users in Western Australia and sits within a broader mixed-method research project involving survey, in-depth interview and document analysis. The project involved an online survey of self-defined ocean-users, using the software Survey Monkey. The Human Research Ethics Committee of the University of Wollongong approved the survey design. Recruitment took place first through contacting a number of WA ocean-user groups and associations to request their support and assistance in circulating the survey. The organisations that responded were Surfing WA, Surf Life Saving WA, WA Game Fishing Association, WA Undersea Club, and the WA government Department of Fisheries. All but the Department of Fisheries agreed to circulate the survey to their member lists or post a link to the survey on their websites. Second, following direct recruitment, social media, including Twitter, Facebook, and our institutional blog ('Conversations with AUSCCER', <http://www.uowblogs.com/ausccer/>) were used to promote the survey. These two techniques led to further recruitment through snowballing. The survey was completed by 557 WA ocean-users, between March 2013 and January 2014. The majority of responses were collected in March (n=401) and July (n=121) 2013.

The survey included 37 questions, grouped into four themes: (i) ocean use; (ii) encountering sharks; (iii) ocean use and the presence of sharks; and (iv) negotiating sharks and human ocean use. Basic demographic information was also collected through the survey to enable understanding of the sample and to contribute to cross-tabulations during analysis. No single question required an answer, so response numbers varied between questions. Sample questions are presented in Table 1.

Table 1. Sample survey questions.

Theme	Question
Your ocean use	What ocean-based activities do you participate in? During the time of year that you use the ocean most, how often do you participate in the activity?
Encountering sharks	Have you ever encountered or sighted a shark when undertaking ocean-based activities? If 'Yes' how many times have you encountered or sighted a shark? Were you able to confidently identify the species?
Your ocean use and the presence of sharks	Does the existence of sharks in WA waters influence your ocean use? If 'Yes', how does the existence of sharks influence your ocean use? Do you currently do any of the following with the aim of reducing the likelihood of encountering sharks? [from a list of precautionary actions compiled from government, scientific, ocean-user group and media sources]
Your thoughts on negotiating sharks and human ocean-use	Please indicate the extent to which you support or oppose each strategy [from a compiled list of shark management strategies suggested by the WA government, marine scientists, ocean-user groups, and the media] Do you have any comments on how we could most effectively and ethically manage sharks and human ocean use?

5. Results and discussion

5.1. Ocean-users and ocean use

Survey respondents (n=557) participated in a range of ocean-based activities, including body-boarding, fishing, paddling (canoe, kayak), scuba diving, snorkelling, spear fishing, surfing, Surf Life Saving, swimming and other activities. The most popular reported activities were swimming (n=413), followed by snorkelling (n=310), fishing (n=235), scuba diving (n=228), and paddling (n=196) (see Table 2). The frequency of ocean use varied with activity. Activities undertaken at least once per week by most participants, at the time of year of their peak ocean-use, were swimming, Surf Life Saving, surfing and spear fishing. Swimming was reported as the most common activity by both number of respondents and frequency, with 124 respondents (34% of swimmers) swimming two to three times per week (Table 3, Fig 1).

Table 2. Ocean-use activities.

Activity	Response count	Response percent
Body-boarding	100	19.0%
Fishing (line, net)	235	44.8%
Paddling (canoe, kayak)	196	37.3%
Scuba diving	228	43.4%
Snorkelling	310	59.0%
Spear fishing	77	14.7%
Surfing	179	34.1%
Surf Life Saving	111	21.1%
Swimming	413	78.7%
Other (boating, body surfing, free diving, jet skiing, kite surfing, photography, research, stand up paddle boarding, wind surfing)	51	9.7%

Table 3. Frequency of ocean use at peak time by activity.

Activity	Multiple per day	Most days	2-3 times per week	Once per week	Once per fortnight	Once per month	Response Count
Body-boarding	1	7	16	18	10	49	101
Fishing (with line, net)	2	5	27	41	50	95	220
Paddling (canoe, kayak)	1	7	51	43	30	58	190
Scuba diving	4	6	32	32	39	98	211
Snorkelling	2	6	30	38	66	122	264
Spear fishing	1	4	10	20	18	15	68
Surfing	3	16	42	45	20	30	156
Surf Life Saving	3	25	38	36	5	6	113
Swimming	13	67	124	75	41	48	368
Other							36

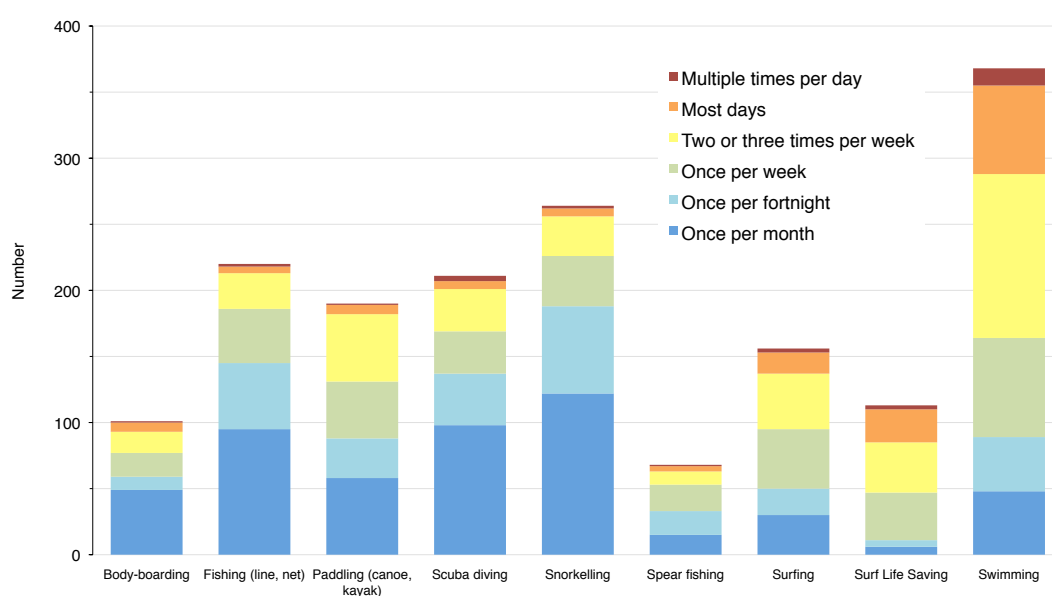


Figure 1: Frequency of ocean use at peak time by activity.

Most survey respondents (99%) used the ocean for recreation. In addition, 25% participated in ocean-based volunteer work, and 22% used the ocean as part of their profession. More than three quarters of respondents (76%, n=398) reported having participated in ocean-based activities for more than 15 years, indicating a high level of personal experience in marine environments. Sixty five percent of survey respondents were men and 35% women. The age range of respondents was 13 to 74, and the median age was 39 (approximately consistent with the median age of the Australian population, which was 37.3 years at June 2013 [ABS, 2014]). The highest level of education of our respondents was: high school (10.1%); TAFE diploma or certificate (21.3%); university degree (43.3%); post-graduate degree (25.3%). Summer (December-February) was the period of highest ocean use, with 97.5% of respondents using the ocean at that time of year, followed by autumn (March-May) (71%), spring (September-November) (70%), and winter (June-August) (43%). These results show that the 2014 and proposed ongoing drumline programs correspond to the periods of highest ocean use in WA.

Importantly, this is not the time during which white sharks – the species most commonly associated with human fatality – are most likely to inhabit the waters surrounding southwest WA. The white shark population in this area spends considerable time foraging across transoceanic ranges (including to South Africa and Australia's east coast), returning to nearshore aggregation areas for periods of time (Bonfil et al., 2005; Weng et al., 2007). In nearshore zones (<50m water depth) white sharks display a preference for temperate waters, corresponding to their main prey species (seals, whales, tuna, salmon etc.), and reflecting physiological features including high metabolism and counter-current heat exchange (Last and Stevens, 1994; Bruce et al., 2006; Weng et al., 2007; Bruce and Bradford, 2012; Robbins and Booth, 2012). Of the 13 human fatalities attributed to white sharks in WA since 1870, ten (77%) occurred between June and November, corresponding with the time of year when sea surface temperatures are at their coldest (<21°C) (Bureau of Meteorology, 2014).

In contrast, tiger sharks are found in greater abundance in warmer waters, above 19°C (Heithaus, 2001). Of the 180 marine animals caught on drumlines in 2014, 163 were tiger sharks. Only 50 animals caught (28%) were target animals – i.e. of target species and size – and all of these were tiger sharks (Dept Fisheries, 2014a). Yet, tiger sharks have not been implicated in a fatality in WA since 1993 (when a pearl diver was believed taken by a tiger shark in Roebuck Bay in the state's far north). Prior to that the previous fatality attributed to a tiger shark in WA was 1925. Of the other species targeted by the 2014 drumline program, one undersize bull shark was caught. Non-target species caught included seven stingrays, five mako, one dusky whaler, one spinner shark, one

northwest blowfish, and one unidentified 3m long animal (Dept Fisheries, 2014a). Despite white sharks being the species most strongly associated with human fatality in WA, the 2014 drumline program did not capture a single white shark. This represents a clear incongruence between the original aim of the WA shark policy – ‘reducing the risk of shark attacks against Western Australian beachgoers’ (Department of Fisheries, 2012) – and the outcomes achieved.

5.2. Encountering sharks

Our research found that 69% (n=352) of respondents have encountered or sighted a shark while undertaking ocean activities. The survey collected data about respondents’ encounters with or sightings of any shark species, while undertaking any ocean-based activity. As such the nature and proximity of encounter varied. Encounters or sightings are frequent: 43% (n=149) of those who have encountered or sighted a shark reported doing so ten times or more; 11% (n=37) reported 100 times or more, or made non-numerical responses such as ‘every time’ or ‘too many to count’. Further, 61% (n=215) of encounters or sightings occurred within the year prior to completion of the survey, and an additional 19% (n=66) within 1-2 years. These results demonstrate that shark encounters and sightings occur often, without harm to people. The frequency of harmless encounters with a variety of species is over-looked by a focus on individual incidents that result in injury or death, distorting the representation of sharks and human-shark interactions.

Most respondents reported undertaking more than one ocean-based activity; as such it was not possible to determine the likelihood of encountering a shark while undertaking any single activity. However, those who participate in spear-fishing – as either their sole ocean-based pursuit or one of several – reported the highest rate of encounter (95%, n=71). Those who participate in Surf Life Saving reported the lowest rate (56%, n=60). For all other activities rates fell between 65% and 80%. Results of Chi-square tests showed significant association between shark encounter and three activities, namely spear-fishing, $\chi^2(1, N=511)=27.26$, $p<.001$, fishing, $\chi^2(1, N=511)=23.57$, $p<.001$, and snorkelling, $\chi^2(1, N=511)=19.34$, $p<0.001$. It is relevant to note that spear-fishing and fishing involve introducing fish attractant (commonly known in Australia as ‘burley’) or blood into the water, which can attract sharks. Spear-fishing and snorkelling are underwater activities, in which visibility in marine environments is relatively good, increasing the likelihood of sighting sharks present in the area. Notably, spear-fishing involves both burley and relatively good underwater visibility. These results present an opportunity to design strategies to reduce risk for specific activities. In the case of spear-fishers, most already employ a range of strategies (discussed below), which could be further promoted. Many spear-fishers remarked that ocean-users should be encouraged to understand risks

associated with the ocean. For Surf Life Savers, strategies could be designed to increase the rate of sighting in order to improve beach safety for others.

Importantly, 73% (n=260) of respondents reported being able to identify the species of shark they had most recently encountered or sighted. Irrespective of whether species were correctly identified, this result suggests that many ocean-users are reasonably well informed about the range of shark species present in an area. Respondents who answered a question about all species encountered or sighted at any time (n=258) reported a wide range of species, including the three species targeted by WA policy and identified as posing a potential threat to people. Specifically, 54% (n=138) of respondents reported encountering or sighting tiger sharks, 23% (n=58) reported white sharks, and 20% (n=51) reported bull sharks. This finding demonstrates that the existence of these species in waters used by people, and interactions between these species and humans, do not necessarily result in injury.

The existence of sharks in WA waters influenced ocean use – positively or negatively – for 48% (n=245) of respondents. Forty-three percent (n=215) reported that the human fatalities of the previous two years and the media coverage associated with these incidents had affected their ocean use; 57% (n=288) reported that it had not. WA ocean-users undertake a range of practices and precautions with the aim of reducing the likelihood of encountering sharks. The most commonly reported strategies were participating in ocean-based activities with other people (57%, n=217) and avoiding the ocean late in the evening (33%, n=125) (Fig 2). In qualitative responses, participants frequently reported other strategies including: avoiding deep water and using the ocean close to shore; avoiding particular places or times, including seal or sea lion colonies, bait fish, whale migration; avoiding overcast conditions, dawn and dusk; checking a variety of shark warning systems and avoiding areas where sharks have been reported; and reducing frequency of ocean use. Several respondents reported avoiding times and places that feel ‘sharky’ (a term they did not define). A small number reported carefully observing sharks and adapting behaviour in response to observations; for example, one respondent noted: *“I am careful to keep an eye out for the sharks’ behaviour and respond appropriately”*. These results demonstrate a willingness on the part of ocean-users to adapt their practices in order to reduce risk.

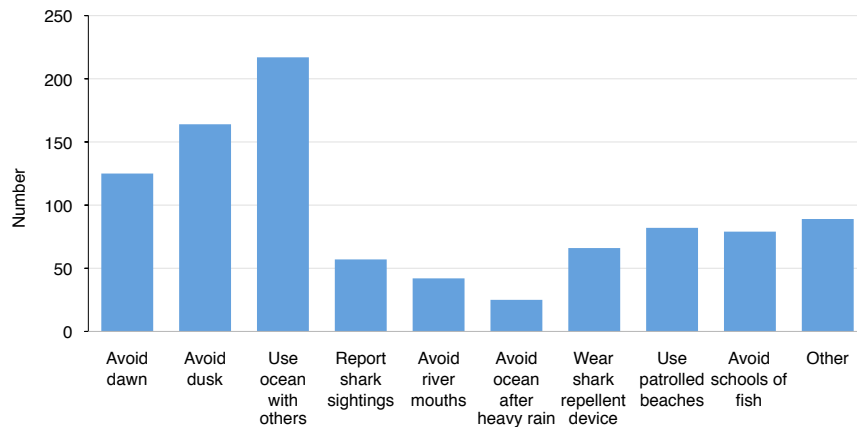


Figure 2: Strategies employed by ocean-users to reduce the likelihood of encountering sharks.

Some respondents reported actively seeking encounters with sharks. Responses to the question ‘How does the existence of sharks influence your ocean use?’ included the following:

“sharks are the highlight of any dive. I sometimes fish for them”

“I love sharks, so am happy to be snorkelling and diving in areas where they are commonly found.”

“I want to see more of them...they are a wonderful creature...unfortunately the media has made them out to be man eaters...that they are NOT!”

“Prefer to dive at sites with a high probability of seeing sharks.”

“It makes me to use it more. Whale Sharking is our main industry, I am a Photographer and being in the water with Sharks is one of my highlights.”

“They are my main target when fishing (sport fishing, all are released alive)”

These results illustrate a variety of positive attitudes towards encountering various shark species. Such attitudes are marginalised in the discourse of threat, risk and injury.

Many respondents demonstrated acceptance of the presence of sharks, and understanding of their important role in marine ecosystems. Most ocean-users take precautions to reduce risk of dangerous encounter. Some describe precautions as sensible or rational; others express regret at feeling a need to change their practice in light of perceived increased risk. For many, being aware of and acting to limit risk is simply part of using the ocean. In a small number of cases ocean-users actively seek encounters with a variety of shark species. These results show that sharks have agency in shaping human ocean use, and in the majority of cases ocean-users are willing to adapt their

practice in order to reduce risk. Such findings are relevant to shark hazard mitigation policy because they can contribute to refocusing debate on the potential for non-lethal hazard mitigation strategies in concert with changing human behaviour in relation to sharks.

5.3. Ocean-users and shark hazard mitigation policy

The third section of the survey sought to understand ocean-users' views on shark management strategies, including WA shark hazard mitigation policy. In September 2012 the WA government introduced policy enabling the Department of Fisheries to 'track, catch and, if necessary, destroy sharks identified in close proximity to beachgoers, including setting drum lines if a danger is posed' (Department of Fisheries, 2012). This came to be known as the 'imminent threat policy'. In November 2013 the government made the decision to deploy a series of drumlines off Perth and southwest beaches (at the boundaries of the MMAs), which would remain in the water between January and April 2014. Following that 'trial' period, the imminent threat policy remained in place; in October 2014 the State and Commonwealth governments reached an agreement that the State government can take immediate action to implement the imminent threat policy 'in the event of a shark posing a threat, or after an attack' (Department of Fisheries, 2014b). As noted above, our survey was conducted in 2013. As such, it captured views of ocean-users about the imminent threat policy prior to the 2014 drumline trial. It is likely that some respondents' views of the policy will have changed following the trial.

Results from the survey showed that on a five-point scale, the largest group of respondents (34%, n=167) strongly opposed the imminent threat policy; a further 19% (n=95) opposed it (Fig 3a). Respondents were further questioned about their views on the policy, in the hope of identifying the rationale for support or opposition. In particular, they were asked if they thought the policy would reduce the risk of ocean-users being killed or injured by a shark; only 17% (n=84) answered yes (Fig 3b). In response to the question 'Does the new policy give you a sense of greater protection and confidence in the ocean', 8% (n=39) answered yes (Fig 3c). Finally, when asked how successful respondents thought the new policy would be in providing tourists to WA with greater protection and confidence, the majority responded that the policy would be unlikely (20%), very unlikely (16%) or neither likely nor unlikely (39%) to do so (Fig 3d). This combination of results indicates that the majority of respondents opposed the imminent threat policy, and did not believe it would reduce risk nor improve protection and confidence for ocean-users.

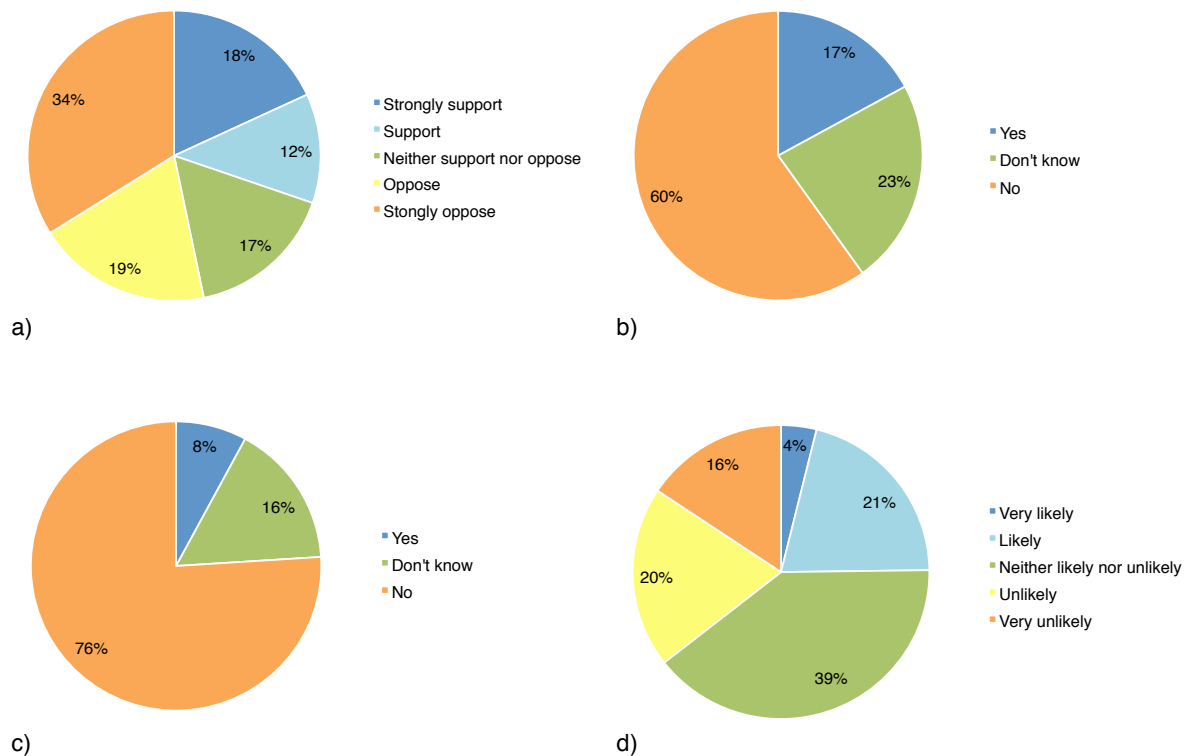


Figure 3: Ocean-users' views of the WA 'imminent threat' policy to 'track, catch and, if necessary, destroy sharks identified in close proximity to beachgoers, including setting drumlines if a danger is posed'. Charts show results of four survey questions: a) What do you think of the new policy? b) Do you think the new policy will reduce the risk of ocean-users being killed or injured by a shark? c) Does the new policy give you a sense of greater protection and confidence in the ocean? d) How successful do you think the new policy will be in providing tourists to WA with greater protection and confidence in the ocean?

In open-ended responses, three themes emerged strongly among those who opposed the policy. The first was that the ocean is the sharks' habitat, home or territory. A subset of this group described sharks as occupying a key role in ocean ecosystems. Second was a group of responses expressing doubt about the effectiveness of the policy, including the suggestion that it would be unlikely to reduce risk. Many questioned the lack of evidence that the strategy would be effective, and raised concerns about specific aspects of the policy. A subset of this group interpreted the policy as a reactive, political act aimed to appease the public. The third theme was that people should understand the risks associated with using the ocean, and make decisions about their activities based on these risks. Some suggested that it is the responsibility of people to adapt their behaviour.

Among respondents who supported the policy two prominent themes emerged. First, a belief that shark populations are increasing, that there are too many sharks in areas used by people, and that reducing numbers would not cause a problem for species. In some cases, this idea was coupled with

a concern about threat posed by individual animals spotted in an area over a period of time (identified as 'rogue' or 'problem' animals). The second theme was qualified support for the policy, including support for tracking but not killing, for tracking and catching for data collection in order to better understand species, and for killing only if a real danger is posed.

Although the majority of ocean-users opposed the new shark hazard mitigation policy, a sizeable minority (30%, n=149) expressed support. This result illustrates the existence of alternative viewpoints on shark management and the complexity of environmental decision-making (cf. Rosenbaum, 2013). However, there was incongruity between support for the policy and expectations about its effectiveness, with a very small proportion of respondents reporting that the policy would reduce risk (17%), or give them a greater sense of protection and confidence (8%). The theme of qualified support described above goes some way to explaining this incongruity. However, it can be further contextualised by two features of the shark debate in WA. First, intensive reporting of shark sightings, encounters and human injury generates a heightened emotional response among some groups of the public (Neff, 2014). During the period of this study, media reports and images of sharks were regular features on television and print media, and these frequently portrayed sharks as indiscriminate killers (Gibbs and Warren, 2014; Neff, 2014). Second, in generating an apparent crisis of ocean safety, public expectation grew around the WA government instituting an appropriate response. As Neff (2014, 2) has argued: 'following shark bites, there are often pressures placed on governments to act'. In this context the WA government acted by implementing new strategies in response to a perceived growing threat. These two factors may contribute to respondents supporting action to mitigate against shark hazards, despite doubting the effectiveness of the specific actions.

5.4. Negotiating sharks

The final section of the survey presented a series of shark management strategies suggested by the WA government, marine scientists, ocean-user groups, and the media, and asked respondents to indicate the extent to which they supported or opposed each strategy (Table 4). The most strongly supported strategies were: (i) improve public education about sharks; (ii) encourage ocean-users to accept the risks of ocean use; and (iii) increase warning systems for ocean-users and beach-goers. The most strongly opposed strategies were: (i) wider use of baited drumlines; (ii) cull shark species identified as posing a threat to humans; and (iii) wider use of shark nets. Notably, all of the strategies that involve killing sharks were opposed overall. In contrast, the most strongly supported strategies

involve public action in the form of ocean-users and broader publics developing understanding, taking responsibility and adapting behaviour.

Table 4. Support or opposition for shark management strategies suggested by WA government, marine scientists, ocean-user groups, and the media. Figures in brackets are number of respondents; figures in bold indicate the largest response group for each question.

Strategy	Strong support	Support	Neither support / oppose	Oppose	Strongly oppose	Don't know / undecided	Response Count
Proactive policy of track, catch and destroy	14.3% (69)	13.9% (67)	10.4% (50)	16.4% (79)	42.4% (204)	2.5% (12)	481
Cull shark species identified as posing a threat to humans	13.5% (65)	11.2% (54)	8.3% (40)	15.1% (73)	49.3% (238)	2.7% (13)	483
Wider use of shark nets	8.2% (39)	14.0% (67)	18.0% (86)	16.9% (81)	38.7% (185)	4.2% (20)	478
Wider use of baited drum lines	9.0% (43)	6.9% (33)	17.3% (83)	20.0% (96)	41.9% (201)	5.0% (24)	480
Improve public education about sharks	55.8% (269)	31.7% (153)	10.0% (48)	1.5% (7)	0.8% (4)	0.2% (1)	482
Improve signage and information at beaches about shark risk	26.2% (126)	34.9% (168)	27.0% (130)	7.9% (38)	2.9% (14)	1.0% (5)	481
Bring an end to 'chumming' waters for shark tourism	41.4% (200)	18.2% (88)	22.2% (107)	7.0% (34)	3.9% (19)	7.2% (35)	483
Develop personal shark deterrent devices	29.3% (141)	38.3% (184)	23.1% (111)	5.2% (25)	2.3% (11)	1.9% (9)	481
Increase aerial patrols over beaches	23.3% (112)	42.4% (204)	22.0% (106)	7.3% (35)	3.7% (18)	1.2% (6)	481
Increase land-based beach patrols / 'shark spotters'	20.0% (97)	35.7% (173)	31.6% (153)	8.3% (40)	3.3% (16)	1.0% (5)	484
Increase warning systems for ocean-users and beach-goers	32.3% (155)	44.2% (212)	19.0% (91)	2.9% (14)	1.0% (5)	0.6% (3)	480
Encourage ocean-users to accept the risks of ocean use	52.8% (254)	29.3% (141)	10.2% (49)	2.9% (14)	4.2% (20)	0.6% (3)	481
Other							43

In open questions about strategies for managing sharks, responses were diverse. However, a number of themes emerged strongly, expanding upon the results reported above. The strongest theme to emerge was greater focus on the research-education nexus. In particular, respondents commented on the need for research into shark behaviour and populations, and into shark deterrents. They described a need for education and improved public information aimed at ocean-users, tourists, and the broader non-ocean-using public, about shark behaviour and mobility, the role of sharks in marine ecosystems, and risks associated with sharks and ocean use. The next most prominent theme related to encouraging people to accept risk. A key part of this is enabling people to understand risk in order to make informed decisions about their activities. This point is therefore linked to the research-education nexus. Other, less prominent but recurring themes included: reducing sensationalist media reporting; improving surveillance and warning systems; removing 'problem' sharks (some respondents noted that reliable scientific information is needed about the existence of such animals); and addressing a perceived ecological imbalance by improving fisheries management to reduce over-fishing, or re-opening shark fisheries. The latter two points indicate a need for better public information about current scientific knowledge of shark behaviour and ecology. Ocean-users demonstrate a strong belief in two key areas: the importance of research, education and improved public information about sharks, risk and deterrents; and equipping and encouraging people to understand risks associated with using the ocean, in order to make decisions about their activities.

6. Conclusion

In Western Australia ocean-users encounter sharks regularly in ways that do not lead to injury. Many take precautions in order to limit risk of dangerous encounter. Shark hazard policy should learn from and encourage these practices. In particular, this study found that using the ocean with others was the most commonly reported hazard mitigation strategy. This practice is important for increasing the likelihood of early sightings of sharks, coordinating a response, and rendering medical aid if needed. Evidence of ocean-users' existing practices and willingness to change behaviour is significant for governments and other institutions devising shark hazard policy. Engaging with ocean-users is vital for resolving the ineffectiveness of and discontent with current lethal approaches.

It is time to move beyond kill-based strategies. The effectiveness of lethal approaches to reduce risk of shark bite is not supported by consistent, convincing evidence. In contrast, the ecological costs for sharks and other marine species are high and well documented. Economic costs are also significant. In addition, our study has found that most ocean-users do not support kill-based strategies for

managing risk. In particular, killing sharks does not make ocean-users feel safer, and they do not think it will reduce risk. Further, many ocean-users question the lack of evidence supporting lethal strategies; they believe that the ocean is the sharks' habitat, and that people should be encouraged to understand risks associated with entering marine environments and adapt their behaviour accordingly.

Shark hazard mitigation policy should instead be evidence-based, and prioritise three areas. First, research focusing on shark behaviour, movement and ecology; shark risks and deterrents and risk avoidance practices; and experiences, practices and cultures of ocean-users. Second, development of education programs and effective public information targeted specifically to ocean-users, tourists, and broader non-ocean-using publics. Effective information also involves reducing media sensationalism and over-reporting of shark activity. Our research points to a number of specific areas wanting of better public information, namely: population status of listed threatened species; ecological roles of apex predators and implications of removing animals from marine environments; and characteristics of perceived 'problem' or 'rogue' animals. Finally, effort should be invested in enabling and encouraging people to understand risks associated with using the ocean, in order that they can make informed decisions about their activities. Many already do, and encounter sharks regularly without ill effect. Policy-makers and broader publics can and should learn from these experiences and practices. Transforming shark hazard policy demands drawing evidence, insight and effort from across the physical and social sciences.

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